BIOLOGICALLY STABILIZED COMPOSITIONS COMPRISING COLLAGEN AS THE MAJOR COMPONENT WITH ETHYLENICALLY UNSATURATED COMPOUNDS USED AS CONTACT LENSES

This application is related to U.S. application Ser. No. 232,749, filed Feb. 9, 1981, entitled Modified Synthetic Hydrogel in the names of P. Kuzma and G. Odorisio. Both of the aforesaid applications for patent are assigned to a common assignee.

BACKGROUND OF THE INVENTION

This invention relates to the preparation of high water content natural hydrogels modified with from about 30 to less than 50 weight percent of a polymerizable ethylenically unsaturated organic compound and to processes for producing the same. In one aspect, the invention relates to shaped articles fabricated from such hydrogels which are useful for medical and cosmetic purposes, e.g., soft contact lenses, therapeutic eye bandages, implants, prosthetic devices, etc.

Hydrogels, i.e., gels which contain water, are well known in the art. They can be formed of various natural substances such as gelatin and the polysaccharides as well as various synthetic polymers such as crosslinked acrylamide polymers, polyelectrolyte complexes, and polymers of hydroxyalkyl acrylic esters. The outstanding biocompatibility characteristic of synthetic hydrogels of acrylic polymers or of unsaturated amide polymers, with living tissue, have made them particularly useful in alloplastic and prosthetic applications. Moreover, properties such as transparency, good optics, shape stability, inertness to chemicals and bacteria, etc., have made such hydrogels of acrylic polymers the material of choice in the production of daily wear soft contact lenses.

Such hydrogels of synthetic polymers can be prepared having a wide variation in certain properties such as water uptake, mechanical properties, gas permeability, optical characteristics, etc. In various applications involving such hydrogels certain properties are desired which are actually in conflict with each other. For example, extended-wear soft contact lenses, i.e., lenses which can be worn for days without removal from the eye as opposed to conventional or daily wear contact lenses which are removed from the eye on a daily basis, desirably should be characterized by high water uptake to achieve good diffusion properties and simultaneously, by good mechanical strength. However, it is recognized in the art that to attain hydrogels of very high water content, e.g., upwards of 90 weight percent, and more, other properties are usually sacrificed, e.g., such hydrogels exhibit relatively low mechanical properties.

Hydrogels of natural polymers such as collagen have not found commercial acceptance in the field of soft contact lenses. In our experiments and experience hydrogels of collagen, within a few days, underwent biological degradation and a general loss of integrity and mechanical properties thus rendering such hydrogels totally useless as candidates for soft contact lenses.

U.S. Pat. No. 3,926,869 discloses the hardening of gelatin for use in photographic emulsion layers by incorporating into the gelatin an acrylic acid-acrylamide copolymer. The layers produced are said to be highly water-swellable.

U.S. Pat. No. 4,060,081 discloses a multilayer membrane useful as a synthetic skin, having a first layer which is a cross-linked composite of collagen and a mucopolysaccharide, to which is adhered a flexible film of polyacrylate or polymethacrylate ester or their copolymers which is flexible and which protects the cross-linked collagen layer from moisture. The collagen-mucopolysaccharide layer is typically produced by dispersing small amounts of collagen, for example, 0.3% by weight, in a dilute acetic acid solution and agitating the solution as the polysaccharide is slowly added dropwise into the collagen dispersion. The collagen and mucopolysaccharide coprecipitate into a tangled mass of collagen fibrils coated with mucopolysaccharide.

U.S. Pat. No. 4,161,948 discloses synthetic membranes for closing wounds, wherein it is disclosed that it is preferable that the α-amino acid polymers employed be cross-linked with a diol, such as polyoxyethylene glycol, in order to have properties resembling those of natural human collagen.

SUMMARY OF THE INVENTION

It has now been unexpectedly discovered that novel shape-retaining, biologically stable hydrogels characterized by at least 50 and upwards to about 70 weight percent collagen (on a dry weight basis) and exhibiting high water content and possessing good mechanical properties can be prepared by the practice of the invention described herein. Such hydrogels have been observed to possess additional desirable characteristics which make them highly useful in the cosmetic and medical areas. These novel hydrogels exhibit high transparency, good diffusion, high oxygen permeability, high optics, inertness to bacteria, biocompatibility with living tissue, good mechanical properties, and other desirable properties.

The present invention also provides a novel process which comprises reacting an aqueous mixture comprising from 50 to about 70, and perhaps slightly higher, collagen and solubilized collagen and less than 50 to about 30 weight percent, ethylenically unsaturated compound, based on the total weight of reactants, under polymerization and/or crosslinking conditions for a period of time sufficient to produce the aforesaid novel shape-retaining, biologically stable hydrogels.

The present invention further provides a novel process for the preparation of novel biologically-stable hydrophilic plastic soft contact lenses, particularly those which can be worn on the eye for extended periods of time, e.g., upwards to several weeks if so desired, and to the novel contact lenses per se.

These and other objectives can be achieved by practicing the teachings herein disclosed and suggested to the art.

DESCRIPTION OF THE INVENTION

It was unexpectedly found in the practice of the invention that there can be produced novel modified natural hydrogel products of greatly improved biological stability having a water content of upwards to about 95 weight percent (based on the weight of the hydrogel) and exhibiting the desirable properties noted above. We have observed that solubilized atelocollagen subjected to gamma irradiation resulted in natural hydrogel products (in the shape of contact lenses) which failed to retain their integrity after two days immersion in a phosphate buffered nutrient media inoculated with 10^5 microorganism/ml (Pseudomonas aeruginosa ATCC